

Multiscale Spatio-temporal Dynamics of the Global Internet

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Project overview

- Goal: **Global Network Situational Awareness**
need explanatory and predictive views of networks
- Challenges: **Collecting, Integrating, Representing**
large, diverse, distributed network data
- New ideas: **Multi-resolution analysis of real/simulated networks** across multiple time scales, topology and protocols with focus on structural mechanisms of the Internet

Today's topic: Model validation

- ❑ From measurements to models to simulations
- ❑ Examples:
 - OSPF
 - Web traffic
 - BGP

OSPF package added to SSFNET

- ❑ Dynamic OSPF capabilities
 - Hello Protocol
 - Database Exchange
 - Flooding
 - Shortest Path calculation
 - Multiple areas
 - Protocol interactions
- ❑ Dynamic OSPF limitations
 - Point-to-point links only
(other link layers in the works)

Protocol conformance testing

- ❑ Identify fault models and important input combinations
- ❑ Identify test purposes according to fault models and protocol specification
- ❑ Design test cases for each test purpose
- ❑ Draw conclusions from tests (no exhaustive testing...)

OSPF validation: strategy

□ Formal testing methodologies

- Drawback: strict requirements on protocol specification and input specification, translation from informal language to formal language
- 548 test cases

□ Informal testing

- InterOperability Lab Test Suite (U of New Hampshire)
- Drawback: no completeness proof
- Advantage: used for real router testing
- 78 test cases

OSPF validation: categories

- ❑ Basic interconnection tests
- ❑ Capability tests
- ❑ Behavior tests
- ❑ Conformance resolution tests
- ❑ Other test types
(performance/robustness/format)

OSPF validation: SSFnet additions

- ❑ Changing of OSPF configuration during simulation
- ❑ Shutting down and restarting OSPF router
- ❑ Simulated link failures
- ❑ Modification of packet header fields
- ❑ Test specific features

OSPF validation: results

- ❑ Possible outcome:
PASSED/INCONCLUSIVE/FAIL
- ❑ Most FAILS/INCONCLUSIVE due to missing features of simulation setup (e.g., lack of multicast support)
- ❑ Some INCONCLUSIVE due to preliminary implementation (e.g., summary LSAs)
- ❑ **Lessons learned**
 - Trustworthy implementation of OSPF
 - Same criteria as actual routers
 - Helped enormously with debugging
 - Two different people for testing/implementation

Web traffic: from measurement to simulation

□ Idea

- Observe user perceived latency from active Web page downloads
- Rebuild scenario in a simulator
- Observe user perceived latency from the simulator
- Compare the results

Web traffic: Approach

- ❑ Web pages
 - Top 100 web sites (according to some measure)
- ❑ Active downloads
 - Multiple downloads from multiple locations
 - Multiple protocol versions
 - Different access speeds
 - Different time of day/time of week
 - Tcpdump trace

Web traffic: Approach (cont.)

□ Simulation scenario

- Extract Web page/embedded objects
- Estimate parameters:
 - Topology: simple network single client/multiple servers
 - Link parameters: delay/bandwidth

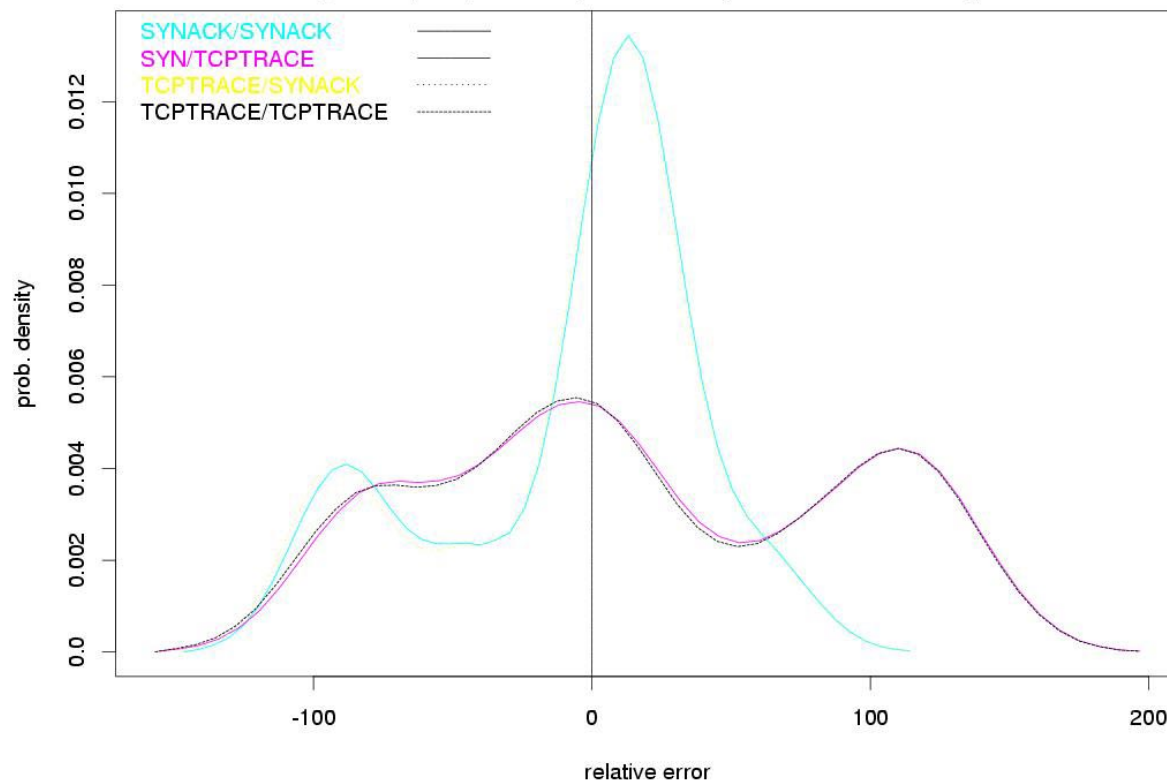
□ Compare the results

- For measurements with/without drops
- Explain outliers
 - Protocol version not supported
 - Network conditions
 - Server behavior
 - Simulator limitations
- Sensitivity study

Web traffic: Result

❑ Lesson learned:

- Decent but not perfect comparison
- Rebuilding the real world is hard



BGP workload model

- ❑ Identify structure of BGP traffic
- ❑ Basis for BGP workload model
- ❑ Tool, RTG, realization of workload model
- ❑ Characterize structure of BGP traffic
- ❑ Verification of tool

BGP workload model: central ideas

- ❑ Updates
 - Instability creators
 - Instability bursts
- ❑ Changes
 - BGP attributes
- ❑ Baseline
 - Routing table
- ❑ Correlation
 - AS-Path

BGP updates

- ❑ Routing instabilities
 - Session establishment/teardown/reset
 - Parameter change
 - Link failure
 - Addition/deletion of prefixes
 - Prefix policy changes
- ❑ Instability creator
 - Two peering ASs, AS, Prefix
- ❑ Instability event
 - ➔ update bursts for set of prefixes
- ❑ Update burst:
 - Single prefix, Set of updates

BGP workload realization

❑ Idea

- Generate updates off-line (stored in file): RTG
- Feed them to system

❑ RTG

- Build routing table
 - Routing table size and characteristics
- Generate BGP attributes
 - AS, AS-path characteristics
- Create BGP updates
 - Event log: session reset, update burst, single update

❑ Parameters

- Configuration files (automatic, semi-manual, manual)

❑ Drive simulation/test system

Summary

- ❑ Exploring Internet dynamics via
 - Measurements
 - Analysis (seeking global effects from noisy data)
 - Modeling/validation and analysis of protocol behavior

A spectrum of new capabilities enable us to investigate the vulnerability of the routing infrastructure

Backup

BGP Metrics: updates

- ❑ Updates
 - Interarrival time, attribute change
- ❑ Update bursts
 - Interarrival time, duration, # of updates
- ❑ Session resets
 - Interarrival time, duration, # of prefixes

BGP routing table

□ Prefix forest

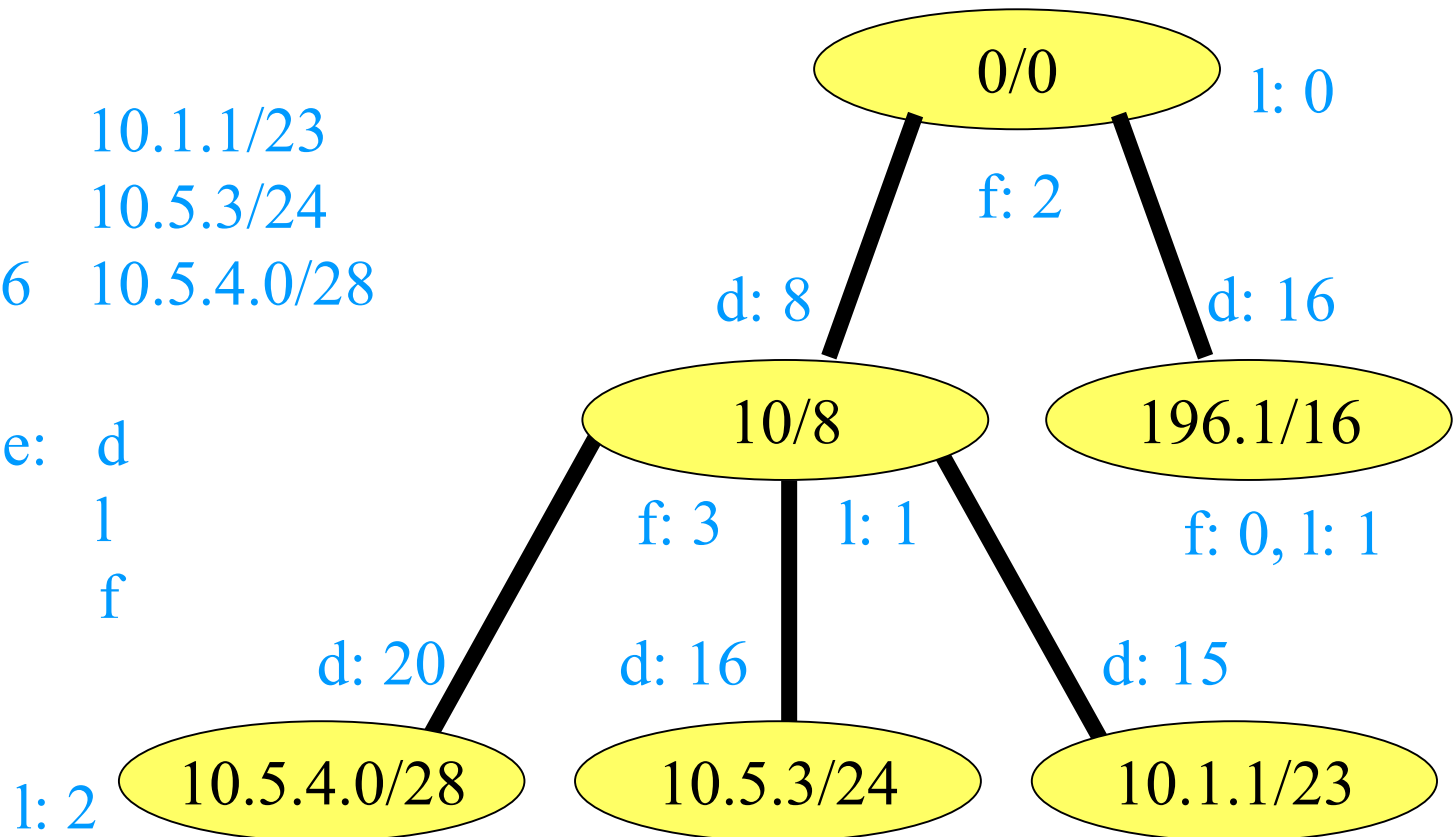
Prefix:

0/0	10.1.1/23
10/8	10.5.3/24
196.1/16	10.5.4.0/28

Distance: d

Depth: l

Fanout: f



Metrics: BGP routing table

- ❑ Routes within IP address range
- ❑ Prefix length
- ❑ Prefix depth
- ❑ Prefix fanout
- ❑ Prefix distance

BGP AS

- ❑ Correlation:
prefix structure and routing instabilities
 - AS, AS-path
- ❑ Characterization AS
 - # of originating routes
 - # of transiting routes
 - Distance of AS to peer
- ❑ Characterization AS-path
 - Length
 - Number of unique ASs
 - Position of replicated ASs
 - Number of replicated ASs